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TÍTULO: Indicadores dicotómicos del modelado de compatibilidad de información educativa.

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RESUMEN: La relevancia de la investigación está asociada con la búsqueda de un sistema no estándar de indicadores innovadores para modelar la compatibilidad de la información educativa. El propósito principal del artículo es describir las propiedades dicotómicas del modelado de compatibilidad de información educativa. El significado práctico y teórico de la investigación reside en que muestra la conveniencia y orden de aplicación de las dicotomías para la selección de parámetros de textos educativos, teniendo en cuenta la multidimensionalidad de las propiedades de la información presentada en los textos. La formalización de las propiedades relacionadas con la compatibilidad del objeto estudiado se realiza de acuerdo con parámetros seleccionados, requisito previo para el desarrollo de programas informáticos aplicados para modelar la compatibilidad de la información educativa.

PALABRAS CLAVES: Dicotomía, modelización, indicador, compatibilidad, información educativa.

TITLE: Dichotomical Indicators of Educational Information Compatibility Modeling.

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ABSTRACT: The relevance of the research is associated with the search for a nonstandard system of innovative indicators for modelling educational information compatibility. The main purpose of this article is to describe the dichotomous properties of educational information compatibility modelling. The practical and theoretical significance of the presented research lies in the fact that it shows the expediency and order of application of dichotomies for the selection of parameters of educational texts, taking into account the multidimensionality of the properties of the information presented in the texts. The formalization of the compatibility related properties of the studied object is conducted according to the selected parameters, which is a prerequisite for the development of computer programs applied for modelling compatibility of the educational information.

KEY WORDS: dichotomy, modelling, indicator, compatibility, educational information.

INTRODUCTION.

Currently, one of the main requirements imposed on the education process is the improvement of the educational environment, which includes educational texts. Analysis of educational texts

becomes the basis for creating a model that takes into account the pedagogical aspect of knowledge transfer as an information in the educational process. The semantic compatibility of educational information is of particular importance due to the interdisciplinary and intradisciplinary connections, by which a unity of pedagogical requirements for knowledge to be mastered is realized.

In its written form, the transmitted knowledge is the coded information of scientific theories presented on any physical medium - in the form of texts in a traditional textbook or on digital means. On the one hand, educational information embodied in textual form is a category of a linguistic nature, which is formally expressed by linguistic means and carries the sense of the content. On the other hand, the broad interdisciplinarity of the highlighted concept requires the specification of its definition relative with regard to the intended scope.

Information transfer of knowledge in the educational process is associated with the need to assimilate meanings, the accuracy of which is determined by the words used. Their perception in the process of knowledge accumulation does not occur at the level of the meanings of the words, but at the level of the semantic content of the subject itself, to which the word is referred.

In this regard, the systemic importance the study of educational information as a category, taking into account the interdisciplinary significance of the phenomenon. It will allow to apply the whole range of approaches specific to individual methods to the educational information and take a fresh look at the problem of learning and the possibilities of influencing the process of perception, transformation and assimilation of new meanings.

We defined the potential aspect of information transfer in the educational process as the product of an adequate assimilation of actual knowledge, involving the transformation and decoding of meanings in accordance with the individual characteristics of perception, including those not realized by the recipient. At the same time, realization of the potential side of this phenomenon should not distort its actual component, but it can provide more options for solving pedagogical problems if

there is an appropriate level of creative (intuitive) thinking, and therefore, an unconscious mental element.

An author of a textbook states a scientific theory adapted for a certain period according to the level of preparation and age of the reader. The author thereby stabilizes the scientific theory by coding information in the form of characters and fixing the phonosemantic field for some time. Its oscillations arise later, with a change in the total volume of the information field falling within the scope of the study. This may occur with the development of science, a change in scientific approaches covered in the educational literature, with the appearance of publications by other authors in the disciplines concerned, with a change in the way the material is presented, etc.

In general, phonosemantic space can be considered from system perspective as a set of elements with their connections and relationships, which under certain conditions can itself act as an element of another set, or which elements can also be considered as systems (Klochkov, Rybakova, 2012).

At that, it can be said that the field structure is formed by the peripheral zones, from which the nearest to the center is generated by a direct semantic connection with the semantic core, and all subsequent structural formations are built on the basis of connections with the previous layers. Bilingual studies show the validity of the “six-step rule”, according to which the connection between two randomly chosen words can be established through no more than five intermediate analogues.

In the phonosemantic space, this rule can be applied to the links between the center and the peripheral layers, thereby indicating the stability and the strength of the internal semantic links. Proceeding from this, it should be assumed that the analysis of semantic compatibility of educational information should include an analysis of the connectivity between the words common in the texts, taking into account the positional distance to the sixth step from the center, which can be the lexical unit with the highest frequency.

In addition, a number of researches (Klochkov et al., 2012; 2018) demonstrated a possibility of studying relationships between the semantic elements arranged in speech in a linear fashion, according to the linguistic patterns (on the syntagmatic axis) and the positional distance between words in sentences, where the distance between them is a characteristic of the logical relation of inclusion (for adjacent words the distance will be equal to one, for every second word - two, etc.). The arithmetic mean of an empirical set of values will be taken as the final result of its determination. Given the six-step rule, this distance should be in the range of 1 to 6.

It should be mentioned that the applicability of these methods to analyse the key lexical units is justified by the specifics of the educational information, which, by a number of parameters, significantly differs from other types of information as it is filled with terms and definitions. Terminological saturation in the process of knowledge transfer is a condition for the unambiguous interpretation of the transmitted and perceived content. In addition, the use of special terminology leads to a high degree of condensation of meaning in the words and stable combinations, and also significantly increases the frequency of their use.

The transfer of scientific theories to the level of student's perception level is an act of coding, the optimality of which is provided by an adequate method of folding the information in the form of terms and concepts without losing sense and with the consideration of recipient's characteristics. The consistent increase in the specialized thesaurus based on the continuity and compatibility of large theoretical blocks makes them more adapted for perception and acquisition. The lack of compatibility, in turn, reduces the possibility of decoding the content basis of texts in the textbooks. Specifics of the chosen approach towards the modelling of educational information semantic compatibility lies in the study of the object as those possessing multidimensional complexity.

The informational nature of an educational text possesses all features of a system. This is a prerequisite for the formalization of the study object and the application of mathematical methods of analysis thereto. The psychological characteristics of the perception and acquisition of educational information with the consideration of the unconscious factor, have become determinants for the selection of the compatibility parameters of the semantic side of educational information within the scope of this study.

Identification of connection and isolation indicators by levels of certainty and ranks of invariance has been carried out providing for the elimination of parameters of duplication and their interdependences, as well as ensuring practical feasibility and efficiency of their application. Hierarchical assignment of indicators of compatibility forms optimal conditions for formalized analysis.

The presented research is aimed at finding a set of innovative indicators for modelling the educational information compatibility, considered in aggregate as a system. Non-standard group of these indicators is due to the nature of the category in question.

In this study, the relevance of the dichotomous approach used for the formation of a system of indicators is dictated primarily by the need to formalize these parameters for further modelling and development of computer programs for processing and analysing educational texts. Thus, the research has both theoretical and practical significance in regard to such an object as an educational text of multidimensional complexity. The main purpose of this article is to describe the dichotomous properties of educational information compatibility modelling.

Materials and methods.

The main method for selecting informative parameters of knowledge formalization is the method of dichotomies, known from the time of the ancient philosophers (Zeno's paradox) and to the contemporary times: contradicting judgments in psychological testing; sequential division into two

in mathematics and others; as mutually exclusive logical classification of various objects into two components (Ananishnev, 2010; Delimova, 2013; Zakharova et al., 2010; Klochkov et al., 2012, 2018; Klochkov, 1999; Lodatko, 2010; Hammond, 2003; 2003; Kamozaet al., 2005; Klochkov, Zaitsev, 2013; Klochkov, Petrova, 2005). The system and parametric version of the system approach used in the study within the framework of the dichotomous analysis allows solving a number of specific application tasks in modeling: automated identification of some aspects associated with the complexity of scientific writing, algorithmic analysis of conceptual and terminological research apparatus, etc. (Klochkov et al., 2012, 2018).

Literature review.

Analysis of the literature data allows to state that the problem of streamlining the parameters for modelling educational information based on the binary method has not been fully studied, especially in terms of compatibility. Only text compatibility issues have been considered previously (Vasilyeva, Krotova, 2014; Klochkov, 1999). It should be borne in mind that the parameters of educational information are not reduced only to the properties of texts, diagrams, tables, figures and drawings.

Beyond these parameters, there are unresolved issues associated with the search for dichotomous parameters based on analytical indicators, methods of mathematical programming and distinguishing of formal analogs of low, medium and high order from among them (Ugrinovich, 2017; Tsyganov, 2010; Harmer, 2001; Kobozeva, 2004; Ohmae, 2005; Posner, McLeod, 1982; Sonesson, 2003).

Until now, the pedagogical literature has not searched for the totality of the most common dichotomies, which would make it possible to conduct a productive search for indicators of educational information compatibility modelling.

Our study is devoted to studying of these problems. The missing description of the dichotomies in the scientific literature and the practical need for it dictated the necessity of the pedagogical research. The study employs the group of dichotomies, indicating the multidimensional complexity of the analysed compatibility of educational information (Ananishnev, 2010; Barakhsanova, Nikiforov, 2018; Vasilyeva, Krotova, 2014; Dakhin, 2002; Klochkov, 1999; Klochkov, Rybakov, 2012; Uvarov, 1996; Kamoza, et al. 2005; Klochkov, Zaitsev, 2013; Klochkov, Petrova, 2005; Mandelbort, 1976; Kasteyeva, 2018).

The *abstract-specific* dichotomy (Uvarov, 1996) is a reflection of the relationship between the simple and the complex, the dialectical principle in which is realized by ascent in the process of cognition from the first one to the second. From the perspective of semantic compatibility, the simple or abstract can be considered as a primary thesaurus, which basis makes it possible to ensure a consistent increment of pedagogical terminology with the meaning accumulated in it. The pole of the *specific*, towards which the process of cognition is moving, is that cumulative scientific theory, which is the inner filling of large arrays of educational information to be studied.

Adaptive - non-adaptive polarity (Klochkov, Rybakova, 2012) is a logical continuation of the previous pair of educational information properties dealing with its content component. The process of adapting the sense of meaningful information is provided by the terms used, which frequencies range in educational texts makes it possible to operate them in the analysis similarly to the keywords.

Deterministic - non-deterministic opposition (Klochkov, Rybakova, 2012; Kamoza et al., 2005) is functionally connected with another pair: *organized - stochastic* (Mandelbort, 1976).

From the perspective of the information modeling, the deterministic parameters include input parameters of the object, which can be measured relatively accurately; Stochastic values determined by probability and mathematical expectation, are attributed to the non-deterministic ones. If the whole model can turn out to be stochastic; then, the output characteristics can take both probabilistic

and precisely determined values. The frequency index and the frequency rank for the keywords will be the quantities that are precisely determined at the empirical level and reflect the deterministic component.

Actual – potential dichotomy (Klochkov, Zaitsev, 2013; Klochkov, Petrova, 2005) involves such qualitative characteristics of educational information as timeliness, which reflects the need to ensure its importance at a certain time period, and the need for achieving didactic goals. The relevance is assumed as a consequence of the educational significance of the scope of necessary knowledge reflected by the authors in educational texts.

The implementation of the *intensional - extensional* dichotomy interaction (Ananishnev, 2010; Klochkov, Rybakova, 2012) is provided by the multidimensional complexity inherent in the object of analysis due to its interdisciplinary nature and the ambiguity of the "educational information" concept. The necessity to apply a variety of logics allows to analyse the semantic compatibility in two directions - in depth (intensionally), and in breadth (extensionally) (Barakhsanova, Nikiforov, 2018; Vasilyeva, Krotova, 2014; Klochkov, 1999; Iravani et al, 2015).

Logical – illogical interaction (Dakhin, 2002) is realized when structuring the educational information. Logical links should be provided with the textual content of the educational text by intra- and interdisciplinary thematic plan. It is possible to determine the optimal sequence for studying the material with the maximum reduction in the number of broken logical connections.

The *discrete-continuous* dichotomy (Klochkov, Rybakova, 2012; Klochkov, 1999) is realized relative to the field phonosemantic space, which forms a single continuous structure of discrete and sign characters around the semantic core. The measure of the relationship between elements of the system is determined by comparing the frequency of keywords (semantic core) and the use of other lexical items grouped with them. The more the distance between the core and the periphery of the field, the less the intensity of internal links, and new external components appear for this field.

The psychological aspect of messages acquisition, manifested as a phonosemantic field, specifies the dimension of the *conscious - unconscious* complexity. Discrete elements of the phonosemantic field have different emotional-motivational workload - positive or negative valences of characters and their combinations affect the unconscious mental sphere. With a negative valence, information is rejected at the psychological level, it is difficult for perception; with a positive valence - it attracts and arouses interest. The research (Klochkov, Rybakova, 2012) revealed the possibility of analysing the interaction of conscious and unconscious perception of textual information through a subjective assessment of the phono-semantic field (SAPF) and the integral coefficient of the phono-semantic field.

Results.

To characterize educational information, it is required to apply a set of indicators characterizing its different levels - from individual characters to the text as a whole, which makes it possible to divide this block of compatibility parameters by gender. The dimension of the complexity is determined by the *hierarchical - linear* dichotomy (Klochkov, 1999). It is based on the hierarchical structure of educational information transferred to the media with the help of characters and their combinations of varying degrees of complexity. The first genus covers the indicators of properties and relationships of characters and their combinations; the second involves the indicators of properties and relations of word forms and their groups; the third deals with sentences; and the fourth - with the text as a whole.

In the *invariant - variable* dichotomy (Klochkov, Rybakova, 2012; Klochkov, 1999), the interaction of the properties of the analysed object, which has an unchanged or changing nature, is manifested. In this case, it should be borne in mind that the meaning that undergoes transformation in the process of its transfer to the final consumer, in fact, is a variable category. Moreover, the knowledge is invariantly fixed by the author on a certain time interval. In the course of compatibility modelling,

it should be kept in mind that the use of mathematical methods of analysis first involves dealing with the form of an expression, namely with a character structure that captures the external side of the transmitted meaning - words and word forms, in other words the original invariants.

The *encoded-decoded* dichotomy is directly connected to the process of transmitting and receiving the information. In particular the study (Klochkov, Rybakova, 2012) shows that the semantic fullness of the text is a distribution function set by the author in a multidimensional space. This function depends on the appearance of corresponding filters in a certain situation that contribute to the acquisition of new meanings of compatibility of the received educational information.

The relationship of the dialectic interaction of the dichotomous dimensionality of the complexity: *dynamic - static* - is manifested in the fact that the marginal formalization of indicators of educational information compatibility makes it possible to fix at the time of the study a certain static state of the system being studied, which is in reality subject to dynamic processes. This is due to the nature of knowledge, which is constantly changing objectively following the realities, and subjectively - as transforming in the consciousness of the recipient in the process of perception. As a result, the ratios of the compared values change, the selected indicators lose their stability to adequately display the modelled properties and relations. Therefore, the model being developed is always updated with the consideration of level of science development at the time of the study.

Indicators of preliminary analysis of the educational information can be ranked by the level of invariance and refer to the first level of certainty (they describe the composition and properties). To make the analysis complete, the model should take into account indicators of the second level of certainty (relationships in the system).

The leading relation is the compatibility, which is realized in the *coherent - isolated* dichotomy (Vasilieva, Krotova, 2014; Klochkov et al., 2012; 2018). The indicators of the second level describing this duality of certainty will be considered in two basic groups at three levels of

compatibility in the following sequence: indicators of isolation will be analysed in the first group of parameters, indicators of connection and frequency correlation will be analysed in the second group (Vasilyeva, Krotova, 2014; Klochkov et al., 2012; 2018; Ardakani et al, 2015). This selection of the parameters arose as a result of the implementation of the *structured-unstructured* dichotomy.

Indicators of isolation: the general parameter of direct isolation of the 1st type of information from the 2nd one, which includes the parameters of their isolation; total coefficient of reverse isolation of the 2nd type of information from the 1st type with the same set of isolation parameters.

Connection indicators and correlation of their frequencies: general parameter of direct linear connection of the 1st type of information with the 2nd one with the indication of connection parameters; general parameter of the inverse linear connection of the 2nd type of information with the 1st type, including the connection parameters. The total frequency correlation coefficient covers the frequency correlation coefficients.

Up to the fourth grade, the disciplines which ensure the formation of general educational competencies, are based on a thesaurus accumulated in a kindergarten or family. At the same time direct and reverse connection of educational texts is in a linear relationship. Starting from the 5th grade, the complexity of educational information demonstrates a noticeable increase, which implies a high probability of the nonlinear nature of direct and reverse connection and allows you to calculate it as the Cartesian distance between the points of N -dimensional space. The reference conditions for such a definition are the presence of the set (X) consisting of characters and having the dimension $|X| = N$ and two texts f and g , incorporating a character (x) from the specified set X , which is used in both texts with frequencies $f(x)$ and $g(x)$, respectively.

To analyse the closeness of the connection with a linear relationship between the variables, the Pearson correlation coefficient is used to detect the presence (absence) of the connection and

determine its positive (negative) value with the minimum error at the normal distribution of the characters. The Cartesian distance formula is applied for more complex educational texts.

The *material-ideal* dichotomy (Klochkov, Rybakova, 2012) is a correspondence between the material form of presented educational information in the form of a text represented in the textbook, and the model of this text stratified by the study levels, of which the target one is a statistics of semantic compatibility.

Inadequate - excessive dichotomy (Klochkov, Rybakova, 2012; Barakhsanova et al., 2017) touches an important aspect of educational information that is significant for the process of transmission and which is embodied in the qualitative characteristic of *sufficiency* or *completeness*, providing the minimum content necessary for making an optimal decision. The quantitative expression of this opposition is manifested in the parameter of educational information redundancy.

Discussion.

Selection of method for educational information content implementation should be carried out to ensure the quality requirements imposed on it: accuracy, reliability, representativeness.

Accuracy is determined by the correspondence of the material to the actual state of the object being described.

Reliability implies the presence of deviations within permissible values that do not distort the meaning of messages.

Representativeness is based on the ability of the stated material to maintain the structure and properties of the displayed object in accordance with didactic objectives.

The *form - content* dichotomy (Klochkov, Krotova, Malkova, 2018) is most important for modelling the compatibility of educational information, allowing to formalize the most difficult component of this transformation. This is possible due to *the coefficient of content (C)* - a parameter that is considered one of the most important for the analysis of the semantic aspect of information. It is

essentially a thesaurus measure, based on the ability to perceive the semantic aspect of the incoming information (S) by the recipient.

In extreme situations, when the recipient's thesaurus is zero ($S_p \approx 0$), his possibilities of perceiving new information, its interpretation and acquisition will also be close to zero; and vice versa, with an unlimited thesaurus, when the subject knows everything ($S_p \rightarrow \infty$), there is no information that can broaden his thesaurus.

Considering the above, the compatibility of semantic information does not imply an equal number of semantic bearers in sequentially studied texts and a single set of keywords, but a gradual expansion of semantic links with respect to the initial basis of terms. In this case, it becomes possible to reconcile the values of the thesauruses S and S_p , which optimize the process of decoding meanings. The measure of semantic information is the coefficient of its content (C). Its value is defined as the ratio of the amount of semantic information to its volume. With a higher value of conciseness in the process of coding information for its subsequent transmission, less data transformations in the system are required, which allows to optimize the process.

The parameter of the amount of information that is included in the formula of the content factor is determined by the quantity, the reverse of which is *entropy*, which is the uncertainty of the system. In the frameworks of our analysis, it is a reflection of the missing information. Its increase occurs at the decrease of uncertainty. This dependence shows another dimension of the complexity of the object under the study, which is defined by the dichotomy as *entropic - non-entropic* (Klochkov, Krotova, Malkova, 2018; Barakhsanova et al., 2017).

The *whole - fragmentary opposition* (Klochkov, Rybakova, 2012) points to the need to combine all indicators characterizing different states of educational information as a system to reproduce a complete image of the multi-level structure of the object being modelled, which becomes possible when introducing the integral coefficient of educational information compatibility (ICEIC).

The contradiction that completes the above analysis can be considered as a *target – result* pair (Hammond, 2003). This opposition combines didactic aggregates of various rank of objectives and possibilities for modelling educational information that ensures its representativeness.

Summing up the choice of identifiers of educational information that describe different sides of its manifestation, it can be noted that their combination has formed on the basis of the selected complexity pairs. This combination of compatibility modelling parameters covers the syntactic, semantic, and, to a certain extent, pragmatic aspects of information. It allows to create a model, the target state of which can be oriented in all three directions, inherent in the process of dichotomous formalization itself - understanding the object being modelled, managing of this object and prediction of changes in its state.

To build a model of educational information compatibility in the very initial approximation, without specifying all levels of analysis, the abstractly designated construct can be represented in the following symbolic form, as it is usually designated in the system and parametric version of the system analysis. This level of approximation is zero and the model of compatibility analysis of educational information at this level of approximation ($z=0$) can be represented as follows:

${}^u_r S_p^z$, where:

S - is a symbol of educational information compatibility analysis;

u - is the current parameter of the level of certainty (1-2);

z - is a variable characteristic of the level of approximation (0 and more);

r - is the index of the genus of the character combination (1-4);

p - is the current indicator of educational information compatibility parameter.

The next level of approximation of educational information modelling ($z=1$) can be based on levels of certainty, when the analysis of educational information is carried out at the first level of certainty

- the composition and properties of the object; on the second - the relationship of connection and isolation.

Then, the number of levels of approximation should correspond to a hierarchy of objectives. The more detailed the objectives and levels of analysis, the greater the number of computer subprograms may be needed to ensure the realization of the general objective.

CONCLUSIONS.

Thus, based on the results of determining a set of parameters for modelling compatibility of educational information, we can make a conclusion that the use of dichotomous division allowed:

1. To fully cover all the dimensions of the complexity of the phenomenon being studied with the aim of formalizing its properties.
2. Contributed to the elimination of duplication of parameters and their interdependencies and provision of practical feasibility and efficiency of their application.
3. By virtue of the hierarchical definition of the compatibility indicators, it helps to optimize the conditions of formalized analysis when developing computer models.

The invariant properties identified in the course of the study confirmed the universality of the application of the method of dividing an object into two mutually exclusive parts. It is expedient to use it as a general scientific kind of analysis in the humanities, the natural-mathematical and the technical sciences.

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